RTCA Special Committee 186, Working Group 3

ADS-B 1090ES MOPS

Meeting #23

Proposed Changes to DO-260A Environmental and Performance Tests

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SUMMARY
There are several tests which appear to have some inconsistency or that need additional clarifications. This Working Paper discusses proposed changes to the following test procedures: §2.4.4.3.4.7.1, §2.3.2.4.6, §2.4.4.3.1.2, §2.3.2.4.3, §2.4.4.3.4.7.3, §2.3.2.4.7

Issue #1 §2.4.4.3.4.7.1 Verification of Criteria for ADS-B Message Transmission Pulse Detection (§2.2.4.3.4.7.1 and §2.2.4.3.4.7.2)

Overview:

The issue is relative to the use of DO-260A enhanced squitter reception techniques from Appendix I. The test procedures in §2.4.4.3.4.7.1 assume a non-enhanced squitter reception method. Therefore the tests are either not applicable or redundant if the tests in DO-260A §2.4.4.4.2.2 are used to verify the enhanced squitter reception implementation.

Description of Issue:

The test procedures in §2.4.4.3.4.7.1 are equivalent to the legacy TCAS Mode S Preamble Reception tests in DO-185A, §2.4.2.1.5.1, which assume a non-enhanced preamble detection implementation.

One of the tests in §2.4.4.3.4.7.1 (Input C, Steps 5 and 6) will fail if the enhanced squitter reception techniques are used. This issue was previously identified in Working Paper 1090ES-WP19-10. In the original issue of DO-260A, the same waveform was used as part of §2.4.4.4.2.2, Input D. This waveform was subsequently removed and replaced with a new set of waveforms as part of "Change 1 to DO-260A."

The other waveforms and tests in §2.4.4.3.4.7.1 are either redundant or equivalent to the tests in §2.4.4.4.2.2:

- §2.4.4.3.4.7.1 Input A (Steps 1 and 2) is similar and equivalent to §2.4.4.4.2.2 Inputs A and B (Steps 1 through 4)
- §2.4.4.3.4.7.1 Input B (Steps 3 and 4) is identical to §2.4.4.4.2.2 Input I (Steps 17 and 18)
- §2.4.4.3.4.7.1 Input D (Steps 7 and 8) is identical to §2.4.4.4.2.2 Input J (Steps 19 and 20)

Proposed Change

The proposed change would be to add the following note to §2.4.4.3.4.7.1 after the "Purpose/Introduction" paragraph:

> ***Note:*** *This test is not applicable to equipment which uses the enhanced reception techniques. That is, it is not applicable to equipage classes A1, A2 and A3. The enhanced preamble detection requirements for this equipment are tested in §2.4.4.4.2.2.*

Issue #2 §2.3.2.4.6 Criteria for ADS-B Message Transmission Pulse Detection (§2.2.4.3.4.7.1 and §2.2.4.3.4.7.2)

Overview:
This is the environmental version of the same test as was described in Issue #1. The test has the same waveforms as §2.4.4.3.4.7.1.

Description of Issue:
See Issue #1

Proposed Change
The proposed change would take the existing section §2.3.2.4.6 and make this sub-section §2.3.2.4.6.1, which would be applicable to a Class A0 receiver. An additional sub-section §2.3.2.4.6.2 would be added which is based on the test procedures in §2.4.4.4.2.2, and would be applicable to class A1, A2 and A3 receivers. This would be consistent with the proposed approach in Issue #1.

1. Add section title "§**2.3.2.4.6.1 Criteria for ADS-B Message Transmission Pulse Detection for Receivers not using Enhanced Reception Techniques**" after the existing section title §2.3.2.4.6.

2. Add the following note to the after the "Purpose/Introduction" paragraph in the existing section §2.3.2.4.6:

   Note: *This test is not applicable to equipment which uses the enhanced reception techniques. That is, it is not applicable to equipage classes A1, A2 and A3. The enhanced preamble detection requirements for this equipment are tested in §2.3.2.4.6.2.*

3. Add the following section after the existing section §2.3.2.4.6 and prior to section §2.3.2.4.7:

   §2.3.2.4.6.2 Criteria for ADS-B Message Transmission Pulse Detection for Receivers using Enhanced Reception Techniques

   Purpose/Introduction:
   These tests verify that the ADS-B reply processor correctly detects the presence of a valid ADS-B preamble whose pulse characteristics are within the allowable limits and rejects preambles having pulse spacing and position characteristics that are outside the allowable limits.

Reference Input:

Provide a method of supplying the UUT with:

Any Valid ADS-B Message having:
"DF" = 17
"CA" = 0
"AA" = Any discrete address
Message Rate = 50 Hz
Frequency = 1090 MHz
Power = -23 dBm (for the first preamble pulse level)

Input A:
Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 1 Input A: Preamble Pulse Characteristics

Pulse	**Rise time** (µsec)	**Fall time** (µsec)	**Δ Width** (µsec)	**Δ Position** (µsec)	**Δ Amplitude (dB)**
1	0.05 – 0.1	0.05 – 0.2	+0.05	-	-
2	0.05 – 0.1	0.05 – 0.2	-0.05	+0.100	+2
3	0.05 – 0.1	0.05 – 0.2	+0.05	+0.100	+2
4	0.05 – 0.1	0.05 – 0.2	-0.05	+0.100	0

Input B:
Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 2 Input B: Preamble Pulse Characteristics

Pulse	**Rise time** (µsec)	**Fall time** (µsec)	**Δ Width** (µsec)	**Δ Position** (µsec)	**Δ Amplitude (dB)**
1	0.05 – 0.1	0.05 – 0.2	+0.05	-	-
2	0.05 – 0.1	0.05 – 0.2	-0.05	-0.100	+2
3	0.05 – 0.1	0.05 – 0.2	+0.05	-0.100	+2
4	0.05 – 0.1	0.05 – 0.2	-0.05	-0.100	0

Input C:
Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 3 Input C: Preamble Pulse Characteristics

Pulse	Rise time (μsec)	Fall time (μsec)	Δ Width (μsec)	Δ Position (μsec)	Δ Amplitude (dB)
1	0.05 – 0.1	0.05 – 0.2	-0.03	-	-
2	0.05 – 0.1	0.05 – 0.2	-0.03	0	0
3	0.05 – 0.1	0.05 – 0.2	-0.03	0	0
4	0.05 – 0.1	0.05 – 0.2	-0.03	0	0

Input D:
Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 4 Input D: Preamble Pulse Characteristics

Pulse	Rise time (μsec)	Fall time (μsec)	Δ Width (μsec)	Δ Position (μsec)	Δ Amplitude (dB)
1	0.05 – 0.1	0.05 – 0.2	+0.3	-0.3	-
2	0.05 – 0.1	0.05 – 0.2	0	-0.125	0
3	0.05 – 0.1	0.05 – 0.2	+0.3	-0.3	0
4	0.05 – 0.1	0.05 – 0.2	0	+0.125	0

Input E:
Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 5 Input E: Preamble Pulse Characteristics

Pulse	Rise time (μsec)	Fall time (μsec)	Δ Width (μsec)	Δ Position (μsec)	Δ Amplitude (dB)
1	0.05 – 0.1	0.05 – 0.2	+0.3	-0.3	-
2	0.05 – 0.1	0.05 – 0.2	0	+0.125	0
3	0.05 – 0.1	0.05 – 0.2	+0.3	-0.3	0
4	0.05 – 0.1	0.05 – 0.2	0	-0.125	0

Input F:
Same as the **Reference Input**, but having the following preamble pulse characteristics:

Table 6 Input F: Preamble Pulse Characteristics

Pulse	Rise time (μsec)	Fall time (μsec)	Δ Width (μsec)	Δ Position (μsec)	Δ Amplitude (dB)
1	0.05 – 0.1	0.05 – 0.2	+4.5	-	-
2	Pulse Not Present				
3	Pulse Not Present				
4	Pulse Not Present				

Measurement Procedure:
The ADS-B receiver power levels specified in this procedure are relative to the loss at the RF message source end of the transmission line used to interface the RF message source to the UUT receiver input port. For each ADS-B equipage class, the specified power level is adjusted to compensate for the maximum line loss for which the UUT receiver has been designed. For example, if the line loss is 3 dB, then each of the RF message power levels specified in the test procedures is lowered by 3 dB.

Step 1: Preamble Pulse Characteristics set to the Extreme Limits of their Tolerance Range - Part 1
Apply **Input A** at the receiver input and verify that at least 90 percent of the ADS-B Messages are correctly decoded.

Step 2: Preamble Pulse Characteristics set to the Extreme Limits of their Tolerance Range - Part 2
Repeat Step 1 with the signal power level at -65 dBm.

Step 3: Preamble Pulse Characteristics set to the Extreme Limits of their Tolerance Range - Part 3
Apply **Input B** at the receiver input and verify that at least 90 percent of the ADS-B Messages are correctly decoded.

Step 4: Preamble Pulse Characteristics set to the Extreme Limits of their Tolerance Range - Part 4
Repeat Step 3 with the signal power level at -65 dBm.

Step 5: Preamble Pulse Widths set to Out-of-Tolerance Values - Part 1
Apply **Input C** at the receiver input and verify that no more than 10 percent of the ADS-B Messages are correctly decoded.

Step 6: Preamble Pulse Widths set to Out-of-Tolerance Values - Part 2
Repeat Step 5 with the signal power level at -65 dBm.

Step 7: Preamble Pulse Positions set to Out-of-Tolerance Values - Part 1
Apply **Input D** at the receiver input and verify that no more than 10 percent of the ADS-B Messages are correctly decoded.

Step 8: Preamble Pulse Positions set to Out-of-Tolerance Values - Part 2
Repeat Step 7 with the signal power level at -65 dBm.

Step 9: Preamble Pulse Positions set to Out-of-Tolerance Values - Part 3
Apply **Input E** at the receiver input and verify that no more than 10 percent of the ADS-B Messages are correctly decoded.

Step 10: Preamble Pulse Positions set to Out-of-Tolerance Values - Part 4
Repeat Step 9 with the signal power level at -65 dBm.

Step 11: Preamble Single Pulse - Part 1
Apply **Input F** at the receiver input and verify that no more than 10 percent of the ADS-B Messages are correctly decoded.

Step 12: Preamble Single Pulse - Part 2
Repeat Step 11 with the signal power level at -65 dBm.

Issue #3 §2.4.4.3.1.2 Verification of Re-Triggerable Capability (§2.2.4.3.1.2)

Overview:
The test requires the Mode S Reply processor to re-trigger on a higher power level DF-17 squitter which overlaps another DF-17 squitter. However the test limits may not be consistent with similar re-trigger capability tests that are specified in DO-260A §2.4.4.4.2.6.

Description of Issue:
The test in §2.4.4.3.1.2 is similar to the test in §2.4.4.4.2.6 step 3 where a higher power DF=17 overlaps with a fixed offset another DF=17 squitter. The test verifies the ability of the Mode S squitter processor to re-trigger. The differences between the test conditions is shown in the following table:

Parameter	**§2.4.4.3.1.2**	**§2.4.4.4.2.6 Step 3**
Delay of 2nd (overlapping) DF=17 squitter from 1st DF=17	12 microseconds	6 microseconds
Power level of 1st DF=17	MTL + 3dB -50 dBm -30 dBm	MTL + 12dB
Increased power level of 2nd DF=17 over 1st DF=17	+6dB	+4dB +8dB +12dB
Required decoding probability for 2nd DF=17 squitter	0.9 (all tests)	Class A1: 0 (+4dB) 0.49 (+8dB) 0.87 (+12dB) Class A2/A3: 0.26 (+4dB) 0.93 (+8dB) 0.94 (+12dB)

While the test conditions for §2.4.4.4.2.6 do not exactly match this test, it appears that the required decoding probability for §2.4.4.3.1.2 is more stringent than the requirements for §2.4.4.4.2.6. The required decoding probability for §2.4.4.4.2.6 were empirically derived from testing performed by the FAA and documented in SC-186 WG-3 Working Paper 1090-WP-14-14.

ACSS has performed some lab testing on a Class A2 ADS-B receiver which has re-triggerable capability. Both sets of tests listed above were run on the receiver. As a base-line, the ACSS receiver passed all tests for a Class A2/A3 receiver in §2.4.4.4.2.6 Step 3. The tests in §2.4.4.3.1.2 were then run on the receiver with the average decoding probability of approximately 60% for the 3 tests at the different RF levels.

Proposed Change

The proposed change could involve changing the test limits so they more accurately reflect the expected system response. An alternate option would be to use similar test condition such as §2.4.4.4.2.6 Step 3 which empirical data has already been derived (with a S/I of +8dB). The following would be a proposal for change assuming the test was made similar to §2.4.4.4.2.6 Step 3:

1. In the section for the 2nd DF=17 message, change the Power from "-44dBm" to "-42dBm". Change the time from "12.0 ±1.0" to "6.0 ±1.0".

2. In Step 1, change "at least 90 percent" to "at least the reply ratio in Table TBD"

3. In Step 2, change "MTL + 12dB" to "MTL + 14dB"

4. In Step 3, change "-30dBm" to "-32dBm"

5. Add the following table (limits may need to be verified for Step 1 since this a lower RF level):

Table TBD: Success Criteria for Re-Triggering Test with Fixed Position Mode S Fruit

Receiver Class	Class A1	Class A2	Class A3
Minimum Probability, Step 1	0.49	0.93	0.93
Minimum Probability, Step 2	0.49	0.93	0.93
Minimum Probability, Step 3	0.49	0.93	0.93

Issue #4 §2.3.2.4.3 Re-Triggerable Capability (§2.2.4.3.1.2)

Overview:
This is the environmental version of the same test as was described in Issue #3. The test has the same waveforms as §2.4.4.3.1.2.

Description of Issue:
See Issue #3.

Proposed Change
See Issue #3, same solution.

Issue #5 §2.4.4.3.4.7.3 Verification of Criteria for Data Block Acceptance in ADS-B Message Signals (§2.2.4.3.4.7.3)

Overview:

The test is used to demonstrate that ADS-B Messages are accepted when there are no more than 7 consecutive low confidence bits. However there are some ambiguities in the test which may not give the correct result based on the data decoding algorithm.

Description of Issue:

The test injects either 7 or 8 consecutive low confidence bits in an ADS-B Message. The method of injecting a low confidence bit in the message is for those bits to contain energy through both halves of the bit, with the half that would not ordinarily contain energy to have 3dB less than the normal pulse. This is a similar method used for testing TCAS error correction in DO-185A, §2.4.2.1.5.4.

However if a data decoding algorithm such as the base-line multi-sample technique is used, the 3 dB point is on the threshold of one of the bit limits, so it is unclear as to what the test result will be. Appendix §I.4.2.3.1 describes this technique, where the "A" sample is within ±3dB of the preamble window. A bit value of 3 dB less than the normal will have an undermined result. The following 2 possibilities exist:

- If the "no energy" portion of the bit is determined to be within the "A" sample window, the 1Score and 0Score will end up being identical since the "1ChipA" and "0ChipA" will have an equal count. Therefore the bit will be declared low confidence and the value will be a 0.

- If the "no energy" portion of the bit is determined to be less than the "A" sample window but greater than the "B" sample window, then the 1Score and 0Score will be about 50% of an ideal waveform, due to the fact that there will be no counts for the "1ChipB" or "0ChipB". However the bit will still be declared as high confidence with the correct bit value.

It is clear that the intent of the test is to inject low confidence bits, therefore if the "no energy" portion was within the "A" threshold (such as 2 dB), then it would provide the correct result.

One additional issue with this test is that there is no error injected in the message. According to the requirements in §2.2.4.3.4.7.3, an ADS-B Message may be accepted as long as there are no errors without regard to the number of low confidence bits.

From the discussion in the previous paragraph, the baseline multi-sample technique will set all of the low confidence bit values to a 0, so as long as the ADS-B message does not have all zeros in bits 33 to 40, the error correction algorithm will be tested. However if the center sample technique is used, the bit values for bits 33 to 40 will be decoded correctly, so it would be necessary to inject an error.

Proposed Change

The proposed change adjusts the test so that the low confidence threshold is met, and insures an error is present in the squitter.

1. In the paragraph for Input A, change “3 dB” to “2 dB”.

2. In the paragraph for Input A, add the following to the end:
   “The data values in bit positions 33 to 39 shall be chosen so that at least one of these bits will be detected by the UUT with the incorrect bit value.”

3. In the paragraph for Input B, change “3 dB” to “2 dB”.

4. In the paragraph for Input B, add the following to the end:
   “The data values in bit positions 33 to 39 shall be chosen so that at least one of these bits will be detected by the UUT with the incorrect bit value.”

5. In the paragraph for Input C, change “3 dB” to “2 dB”.

6. In the paragraph for Input C, add the following to the end:
   “The data values in bit positions 33 to 40 shall be chosen so that at least one of these bits will be detected by the UUT with the incorrect bit value.”

Issue #6 §2.3.2.4.7 Criteria for Data Block Acceptance in ADS-B Message Signals (§2.2.4.3.4.7.3)

Overview:
This is the environmental version of the same test as was described in Issue #5. The test has the same waveforms as §2.4.4.3.4.7.3.

Description of Issue:
See Issue #5.

Proposed Change
See Issue #5, same solution.